DIAPHRAGM VALVE SEAT

Field of the Invention

[0001] The present invention relates generally to a valve seat for a diaphragm valve, and more particularly to a metal valve seat for a diaphragm valve, and composition and geometry therefor, for withstanding high temperatures and corrosive materials.

Background

[0002] Diaphragm valves are generally known and include a valve arrangement wherein a diaphragm seals against an annular valve seat thereby prohibiting the flow of fluid through the valve. As such, the valve seat is used to seal off an inlet or outlet passageway by engaging with the diaphragm. Diaphragms may be made of metal or non-metal materials.

[0003] Typical valve seats used with metal diaphragms are designed from a plastic based material, such as polychloro-trifluoro-ethene, polyimide, or Teflon™. However, non-metal valve seats have properties that change when subjected to environmental factors outside the parameters of rated use, such as high or low temperature ranges or when the valve seat is exposed to a highly corrosive material. In such aggressive applications, metal valve seats have been used, however, the performance requirements of such known all-metal valves do not typically match the performance of plastic based valve seats. For example, a valve with a metal valve seat may demonstrates a higher leak rate, a decrease in the number of operable cycles, or an increase in the required actuation force. Decreasing the rated number of cycles is a disadvantage, and this disadvantage is even larger for systems operating at high temperature or regulating a corrosive material as replacement costs can be high. This is because the valve is frequently used to control the flow rate of such materials, thus requiring a dramatic increase in the number of cycles required on a regular basis. As such, it is desirable to provide a valve seat that allows for higher rated temperatures or for controlling corrosive materials without compromising the performance of the valve.

Summary of the Invention

[0004] A metal valve seat is provided wherein the valve seat is thermally and chemically inert. In one embodiment, the seat is formed as an insert, while in other embodiments the seat may be integral. The seat may optionally include an edge or other protrusion that can penetrate, dig into or otherwise tightly engage a portion of the valve body, thereby securing and sealing the valve seat in place. In another embodiment, the seat is formed such that it is harder than the

diaphragm. In one such embodiment, at least some portion of the valve seat is case hardened or optionally through hardened. In one embodiment, the valve insert has an inner diameter that is flush with the diameter of a fluid passageway disposed within the valve body thereby forming a continuous flow path.

[0005] Another aspect of the present invention is a method of staking a valve seat insert, in particular a metal valve seat insert. In one embodiment, the valve seat insert includes an edge or protrusion located on the periphery of the valve seat body. The method includes inserting such valve seat into the valve body and clamping a portion of the valve body down on the valve seat, thereby driving the valve seat edge into another portion of the valve body. This method further provides a seal between valve seat and the valve body.

Brief Description of the Figures

[0006] In the accompanying drawings, which are incorporated in and constitute a part of this specification, embodiments of the invention are illustrated, which, together with a general description of the invention given above, and the detailed description given below serve to illustrate the principles of this invention.

[0007] Figure 1 is cross-sectional view of a prior art diaphragm valve having a polymeric valve seat;

[0008] Figure 2 is a cross-sectional view of a diaphragm valve including a metal valve seat insert and a staking apparatus;

[0009] Figure 3 is detailed cross-sectional view of the valve seat insert as shown in Figure 2;

[00010] Figure 4 is detailed cross-sectional view of the valve seat insert and the seal provided between the valve seat and the diaphragm; and

[00011] Figure 5A-5B are view showing the staking of a metal valve seat employing only the outer stake.

[00012] Figure 6 illustrates a replaceable metal valve seat.

[00013] Figure 7 illustrates an integral metal valve seat.

Detailed Description

[00014] With reference to Figures 1, a diaphragm valve **10** is shown having an inlet passageway **12**, an outlet passageway **14**, a diaphragm **16**, an actuator **18** and a polymeric valve seat **20**. The remainder of the diaphragm valve **10** is of general construction and can be a variety

of different embodiments. These embodiments are not discussed further in this application as they do not pertain to the inventive aspects covered in this application. As such, the scope of this application should not be limited by any additional aspects of the diaphragm valve not specifically discussed herein. The present invention replaces the polymeric valve seat with a metal valve seat, either integrally formed or formed as an insert. In doing so, the valve seat may be hardened to improve cycle life, or, in the case of an insert, may include an alternative staking and sealing means, or may include a combination of these features.

[00015] Figure 3 shows a close-up view of the valve seat **20**. As shown, the valve seat **20** is typically a separate component that is placed within a valve seat recess **22** located within the body **25** of the valve **10**. The valve seat **20** rests between inner wall **26** and outer wall **28**.

[00016] A known method of staking a plastic seat such that it is sealed between an inner wall and an outer wall, or valve body portion, is disclosed in commonly assigned, U.S. Patent No. 6,092,550. Typically, this staking method cannot be used on the metal valve seat **20** since the deformation will not occur as described in the above-referenced patent, and therefore a seal will not be formed between the valve seat and the valve body. As such, the valve seat **20** of the present invention is specially designed to provide a solid stake, thereby avoiding movement in the seat and creating misalignment with the diaphragm. The solid stake also ensures the metal valve seat will seal against the valve body. Furthermore, the valve seat may include a special top surface **40** for good mating contact with the diaphragm.

[00017] The valve seat **20**, as detailed in Figures 3 and 4, is generally annular in nature and tapers from the bottom of the seat **42** to the top of the seat **44**. The bottom corners **46** of the seat **20** may be beveled to conform the seat against the inner and outer walls **26** and **28**. In particular, the bottom portion of the inner and outer walls **26** and **28** contain radiused or chamfered portions **26a** and **28a** that cooperate with the beveled portions **46** of the seat **20**. The respective beveled portions allow the valve seat to sit flatly in the recess **22** and provides a clearance tolerance for placing the seat within the recess. The top surface **40** has a sloping surface **48** located on either side of the raised sealing surface **50**. The raised sealing surface **50** can either be rounded or flat or may be sloped. The configuration of the sealing surface **50** depends on the diaphragm **16** configuration as the contact between the sealing surface and the diaphragm should provide a seal. Preferably, the seal formed between the sealing surface **50** and diaphragm **16** is wider than line contact, i.e. point contact between the sealing surface and diaphragm along a radius of the diaphragm, thereby ensuring a better seal. This can be accomplished by mating the shape of the sealing surface **50** to that of the diaphragm surface.

[00018] An optional additional feature of the metal valve seat **20** that assists in the staking and sealing of the valve seat is the edge or protrusion **55** that extends from the outer surface **57** of the valve seat. This edge **55** may be sharp in nature, such that it digs into the surface of the outer wall **28** upon the application of pressure. In some embodiments, however, a less sharp or rounded protrusion **55** can alternatively be used providing it secures the valve seat. The protrusion digs into a portion of the valve body thereby creating a body seal along that surface. Although the embodiment shown in the drawings includes an angled protrusion, such angling is not required. By angling the protrusion, it is easier to engage the protrusion with the valve body wall. Also, the angled protrusion provides a downward force into the valve body, thereby providing force to fully seat the insert into the valve body.

[00019] The protrusion **55** may be circumferential, partially circumferential, or can be one or more individual spikes or protrusions. When the outer wall **28** is crimped toward the valve seat **20**, the force drives the protrusion **55** into the surface of the outer wall **28** thereby securing the seat **20** within the valve seat recess **22**. In other embodiments, a plurality of edges or protrusions **55** are used to secure and seal the valve seat **20**. For example, one or more protrusions **55** may be formed to engage the inner wall **26**, the outer wall **28**, or may be formed on a corner or edge of the valve seat or the bottom surface **27** of the valve seat **20**. It is generally preferred to provide the protrusion or protrusions on the outer portion of the seat **20**, as crimping the inner wall towards the seat places tension on the seat and placing the protrusion on the bottom the requires force to be applied to the top surface, or sealing surface of the seat. In another embodiment, the edge or protrusion **55** is forced into the valve seat recess **22** wherein a circumferential, or partial circumferential, indentation (not shown) is located along the valve body side wall to receive the edge or protrusion. An adequate seal may not be formed if the seal is not circumferential. In such cases, an additional sealing mechanism can be used, such as a thin polymeric layer on one or more surfaces of the seat.. In another embodiment, the edge or protrusion **55** is located on a valve body wall, such as the outer wall **28** and digs into the seat to secure and seal the seat in the recess **22**.

[00020] In another embodiment of the present invention, the inner wall **26** can be removed, and the valve seat **20** can be secured to the outer wall **28** by driving protrusion **55** into the surface of the outer wall **28**. Figures 5A-5B show the staking of the valve seat **20** employing only the outer stake **28**. When the outer wall **28** is crimped downward toward the valve seat **20**, edge **55** digs into the stake, thereby securing the seat within the valve seat recess **22**. The inner portion of the seat is thus flush with the fluid passageway at the point of connection. As such, the inner portion of the seat forms a continuous flow path with the fluid passageway. This

embodiment provides the advantage of moving the sealing surface **50** of the valve seat **20** inward toward the flow passageway **60**. By moving the sealing surface **50** closer to the flow passageway **60**, the seal, i.e. the circumferential contact between the sealing surface **50** and the diaphragm **16**, is smaller, perhaps forty percent of the seal otherwise required. With a reduced seal area, the actuator **18** needs to produce less force to provide the seal, thereby increasing the cycle life of the valve. In order to further minimize the seal circumference, the inner portion of the seal can lie along the same axis as the fluid passageway, thereby forming a straight continuous flow path.

[00021] In another embodiment of the present invention, the valve seat, or portions of the valve seat, can be hardened. For example, the sealing surface **50** can be case hardened to provide a seal with the diaphragm **16**. By hardening the sealing surface **50**, the valve may have an improved leak rate and will last additional cycles. This is because the seat will be harder than the diaphragm, and as such, will be less likely to deform from the force asserted by the diaphragm. With the seat being harder than the diaphragm, the diaphragm will wear prior to the seat. This can be advantageous for most valve assemblies as the diaphragm is earlier to replace than the seat. Furthermore, typical valves require a number of cycles in order to conform the seal surface and diaphragm surface to each other to provide for the valve seal. By hardening the sealing surface **50**, less cycles will be required in order to provide the valve seal.

[00022] In one embodiment, the diaphragm is made from Elgiloy™, which has a hardness of about 50 Rockwell C. This embodiment is preferred as it provides the greatest cycle life for the diaphragm. In this embodiment, the seat, or a portion thereof, can be hardened so that it is harder than the diaphragm, and preferably the seat is hardened to at least 55 Rockwell C. In other embodiments, the edge or protrusion **55** of the valve seat **20** can be hardened thereby making it easier to dig the edge into the outer wall **28**.

[00023] Methods and examples of metal hardening procedures are disclosed in commonly assigned, U.S. Patent Nos. 6,093,303 issued July 25, 2000 for LOW TEMPERATURE CASE HARDENING PROCESSES; 6,165,597 issued on December 26, 2000 for SELECTIVE CASE HARDENING PROCESSES AT LOW TEMPERATURE; and 6,461,448 issued on October 8, 2002 for LOW TEMPERATURE CASE HARDENING PROCESSES, and commonly assigned, co-pending U.S. Patent Application No. 09/494,093 filed on January 28, 2000 for MODIFIED LOW TEMPERATURE CASE HARDENING PROCESS, which are hereby incorporated by reference in their entirety. Although the method of hardening described in the above-referenced patents is the preferred method, one skilled in the art should appreciate that other methods of case hardening, or carburization, such as, for example, nitriding, can be used to achieve similar

results. Each of these processes can be used to case harden, selectively case harden or through harden the seat.

[00024] In addition to the hardening methods mentioned above, other hardening methods can be used. Work hardening and roll hardening are some examples of other standard hardening techniques. It may be difficult to achieve the desired hardness level using these standard techniques. However, the seat may be partially work hardened and partially case hardened to achieve the desired seat hardness. Alternatively, the diaphragm could be made of a softer material, thereby allowing use of some of these other hardening techniques. As still another option, the seat can be made from a harder material, such as, for example, a ceramic or crystalline structure, such as sapphire, alumina, or zirconia, or other harder metals, such as cobalt-based alloys or other super-alloys. Yet another alternative would be to coat the metal seat with a hard coating, such as a titanium nitride coating.

[00025] The present invention can find use in other valve assemblies that employ plastic seats, wherein the plastic seat is replaced by a hardened metal seat. For example, a removable plastic is disclosed in commonly assigned, U.S. Patent No. 5,215,286 issued June 1, 1993 for HIGH PRESSURE DIAPHRAGM VALVE, which is hereby incorporated by reference. Using the invention as disclosed in this application, Figure 6 illustrates a removable metal seat **100** inserted into a valve body **102**. The diaphragm **104** seals against seat surface **106**, while the body seal is formed between the diaphragm and the outer portion **107** of the seat **100**. The diaphragm **104** is held in place by the clamping force exerted by the bonnet **108**. The seat is hardened, using the methods disclosed above, such that it is harder than the diaphragm. As such, a strong seal is provided between the diaphragm and the seat. In Figure 7, the valve seat is integrally formed. The diaphragm **204** seals against hardened metal seat surface **207** to seal the flow path. The diaphragm **204** is also secured between the bonnet **208** and the valve body **202**, a portion of which can be hardened.

[00026] Another embodiment of the present invention employs a coated or partially coated valve seat. The seal includes a layer of soft polymeric material molded or deposited on the seal or select surfaces of the seal. The coating can be any suitable plastic, such as, for example, polyfluoroamide or polychloro-trifluoro-ethene. The plastic coating can be used to provide a strong seal between the seat and either the diaphragm or the valve body. In general, a metal seat is used under conditions a plastic seat would not work, such as high temperature. By using only a small amount of plastic coating, the rated temperature for a valve assembly may increase as the valve seat will continue to function until the plastic is thermally degraded. A thin plastic coating

can be placed between the seat, either on the backside or bottom, to provide a good body seal. A thin plastic coating can be place on the seat seal surface to provide a good seal against the diaphragm. The thin coating of plastic may provide improved resistance to chemical swelling, improve resistance to seat deformation, as compared to an all-plastic seat, and improved sealing between metal parts. As another alternative, the seat can be primarily plastic, and a portion can be a hardened metal. This embodiment would have nearly the same thermal restrictions as an all-plastic seat, however may provide improved chemical resistance.

[00027] Although the invention has been disclosed and described with respect to certain preferred embodiments, certain variations and modifications may occur to those skilled in the art upon reading this specification. Any such variations and modifications are within the purview of the invention notwithstanding the defining limitations of the accompanying claims and equivalents thereof. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.